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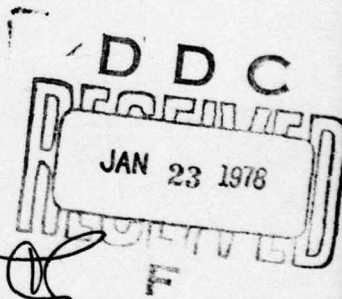
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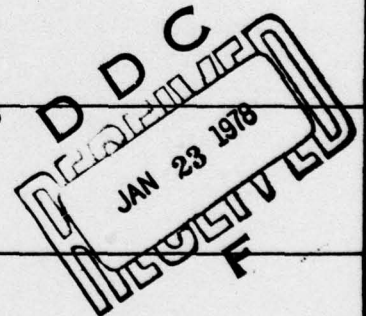
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20. Abstract (cont'd)

photo documentation was developed, and several black and white photographs are included in this report. ←

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PREFACE

This report was prepared by Dr. F. Lawrence Bennett, Head, Department of Engineering and Science Management, and Acting Coordinator, Division of Management Sciences, University of Alaska, Juneau, Alaska. The study was performed under DA Operations and Maintenance Account, Program 7 728012.14, Facilities and Investigations Studies, Work Unit 102, Cold Weather Construction.

The success of a project of the type reported here is dependent entirely upon the cooperation of many persons. In particular, the superintendents of the various projects that form the basis for this study were extremely cooperative in allowing site visitations and data gathering. The author thanks John Compton of Strand Inc., John Moneymaker of Modern Construction Inc., Jerald Lizotte of Nor-Mac Builders, Jim Carlson of Peter Kiewit Sons, Co., Frank Lucas of Tate and Company, Joe Coaty of O.L.Q. and Sons, and Tom Murphy of C.J.M. Construction for their interest and assistance on this project.

Clark R. Milne served as data technician and photographic assistant for the entire project, and his enthusiasm, technical competence and managerial abilities contributed greatly to the success of this project.

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INTRODUCTION

During the winter of 1976-77, over one half million square feet of new construction was in progress in the Fairbanks area. These projects went forward under conditions that, in the past, would have resulted in suspension of construction activities for some or all of the winter period.

On September 24, 1976, the U.S. Army Cold Regions Research and Engineering Laboratory authorized the School of Engineering at the University of Alaska to conduct a study of construction work in the Fairbanks area during the winter of 1976-77. Primary emphasis was to focus on methods used by contractors to protect their buildings under wintertime conditions, to note the construction activities that took place in the winter, and to document the temperatures found inside buildings under construction during the winter.

As stated in the project proposal, the project had three main purposes, as follows:

1. Observe and document typical temporary heating and enclosure methods for different kinds of building construction projects throughout a winter season in interior Alaska.
2. Catalog the kinds of construction activities that are carried out at various temperatures in the winter.
3. Record and summarize temperatures at various locations within several buildings under construction, at different conditions of outside temperature, sky cover, wind, and the like.

The author served as principal investigator for this study, which was active from soon after authorization through May 1977. Data collection for this project took place during the months of November 1976 through March 1977.

The approach taken by the study was simply to visit sites where construction projects were in progress and to record observations made on these visits. Data recorded included date, time, project name and location, outside temperature, weather conditions, persons contacted, activities underway, types of enclosures and types of heating, inside temperatures at various locations, pictures taken, and miscellaneous comments. This information was summarized and, together with the extensive collection of photographs, forms the basis for the report that follows.

The winter of 1976-77 in Fairbanks, Alaska, was far from typical, as it was in many parts of the United States. In Fairbanks, abnormally high temperatures prevailed during the months of November and December 1976 and January and February 1977. For the months of December, January and February, each of whose mean monthly temperatures are normally below 0°F, the mean temperature was +4.71°F, or 13.46°F above normal.

Precipitation conditions were considerably drier than normal; for the period October 1976 to April 1977, total precipitation was 69% of normal. Thus, the report that follows cannot be based on a "typical" Fairbanks winter. Nonetheless, it is believed that the information is an accurate representation of Fairbanks construction during this mild winter. Further, it is believed that contractors would have worked during this winter period, even if temperatures had been considerably colder.

The report begins with a description of the various building construction projects that were studied, then discusses the methods used for providing temporary heating and enclosures on these projects, then summarizes the construction activities that were observed at various temperature conditions, and, finally, reviews the interior temperatures that were recorded at various locations in buildings under construction.

THE BUILDING CONSTRUCTION PROJECTS STUDIED

Nine building construction projects, whose total area exceeded 515,000 square feet, were active in Fairbanks, Alaska, during 1976-77 winter. These projects range from a shopping mall, containing 130,000 square feet and 2,400,000 cubic feet, and a federal office building, containing 154,620 square feet and 1,855,000 cubic feet, to the construction of a series of modular housing units. In addition, three other building projects, which had been started prior to the winter of 1976-77, were not continued through the winter.

Geographically, the nine projects which formed the basis for this study were dispersed throughout the Fairbanks area. Figure 1 is a map indicating the location of each of thirteen projects -- the nine active projects, the three that were inactive and one bridge construction project that was also inactive during the 1976-77 winter.

It is of interest to note that the three building construction projects that were inactive did not progress through the winter for reasons not related to cold weather construction technology. Rather, they suffered either from design delays or financial difficulties. The Fairbanks Memorial Hospital addition, a project containing 78,971 square feet and approximately 1,580,000 cubic feet, was shut down early in the winter because required design drawings had not been completed. Two hotel projects, the Fairbanks Plaza Hotel and the Wicken Hotel, suffered from financial difficulties and were inactive during the winter period. Presumably, all three of these projects would have gone forward during the 1976-77 winter if their design delays or financial difficulties had been alleviated.

The following paragraphs contain general descriptions of the thirteen construction projects available for study in the Fairbanks area during the winter of 1976-77. Reference should be made to Table I, "Construction Project General Information," which contains summary information in tabular form.

BENTLEY MALL

The first project is the Bentley Mall owned by the Barsa Development Company. This shopping mall will be Fairbanks' largest shopping center. Located on College Road near the Steese Highway intersection, the mall contains thirty-two units. The construction features a brick faced exterior, with extensive glass windows and doors. The main building contains wide pedestrian aisle ways. Figure 2 shows a general view of a portion of the main building at the Bentley Mall. The main building contains seventeen small shops and is "anchored" with large (30,000 square feet each) Safeway and Pay 'n Save stores at each end. Two additional buildings contain six and seven shops each. Total volume is approximately 2,400,000 cubic feet, making this project the largest in volume under construction in Fairbanks in winter 1976-77. Total area is 130,000 square feet, the second largest project in area. Contractors on this project included Strand, Inc., Panther Electric Company, W.R. Grasle Company and Arctic Mechanical.

BOROUGH LIBRARY

Figure 3 contains a photograph of the new North Star Borough Library, located at Airport Road and Cowles, taken while work was progressing inside during the winter. Contractor for this project was Modern Construction, Inc.; the project contains approximately 50,000 square feet and approximately 750,000 cubic feet. This structure includes concrete floors and an exterior envelope that consists of paper, glass insulation, and clear heart cedar paneling. In addition to the standard reading/reference area, stacks and offices, the new library facility will contain an auditorium/theater, music rooms and a lounge area.

FAIRBANKS FURNITURE, INC. STORE

Owner and contractor for this retail commercial facility located at College Road and Illinois streets is William Stewart. The project consists of two stories plus a basement, totaling approximately 20,600 square feet or 233,700 cubic feet. The concrete block structure will contain the main sales area on the ground floor, with storage below and offices above.

FAIRBANKS MEDICAL CLINIC

This project is an addition to the existing Fairbanks Medical and Dental Arts Clinic, located at 19th Avenue and Cowles Street, near the Fairbanks Memorial Hospital. A typical medical clinic, the building

consists of two floors of small offices and waiting rooms. Construction by Nor-Mac Builders featured exterior plywood sheathing, a concrete ground slab, vinyl faced interior panels, and complicated laboratory-type plumbing. The area of this project approximates 45,000 square feet; the volume approximates 675,000 cubic feet. Figure 4 shows a general view of the Fairbanks Medical Clinic while under construction.

FAIRBANKS PLAZA HOTEL

This project, owned by Fairbanks Real Estate Development Corporation and Bering Straits Development Corporation, was not active during the 1976-77 winter. Figure 5 shows this project, with its tower crane standing idle; the idleness was due not to winter conditions, but, instead, to financial difficulties. Contractors on this project, located at 1st Avenue and Hall Street, include O.L.Q. and Sons, and Life Systems Corporation.

FEDERAL BUILDING

The largest building construction project underway in Fairbanks during the 1976-77 winter, when measured in terms of area, was the Federal Office Building located on Airport Road at the new Steese Highway. Total area is 154,620 square feet; the project volume of 1,855,000 cubic feet makes the Federal Building the second largest project in terms of volume. This project was built for the General Services Administration by Huffman Construction Company, Western Mechanical, and Peter Kiewit Sons, Inc. In addition to general offices for governmental agencies, the project includes a large parking area, a motor pool deck, and garage facilities. Over 800,000 cubic feet of the total volume is devoted to non-office uses. The structure includes a steel frame and exterior walls of metal sheathing. Figure 6 is a general view of the Federal Building looking southwest at the main entrance which has been covered temporarily with polyethylene sheathing.

HIGHWAY BRIDGE

Although not a building construction project, this project has been included briefly in this study. The bridge carries the new Steese Highway over the Chena River; it is being built for the State of Alaska Department of Highways. Figure 7 shows this project while it was yet shut down for the winter. Tentative plans had been made to erect the remaining steel girders from the ice during the winter period, but unusually mild winter temperatures prevented this approach.

HOSPITAL ADDITION

As mentioned previously, major activities on the hospital addition project were suspended during the winter of 1976-77, due not to severe winter conditions but to lack of sufficient design information to allow the contractor to proceed in a timely manner. Figure 8 shows a portion of the hospital addition project that was completed prior to the winter

shutdown; the existing hospital is shown in the background. The project is located at 19th Avenue and Lathrop Street and is being built by Peter Kiewit Sons Company. Total project area is 78,971 square feet, not including canopies and crawl spaces. Volume approximates 1,250,800 cubic feet.

INTERIOR CITY BRANCH

This banking facility is an addition to the existing Interior City Branch of the First National Bank of Anchorage, located at 8th Avenue and Noble Street. The project was of particular interest in this study, as the general contractor, Tate and Company, elected to erect a polyethylene "shell" around the entire project and work within this enclosure for several months during the winter. The structure includes a steel frame, brick exterior, and concrete floors. The area is 13,500 square feet, and building volume is 202,500 cubic feet. Other contractors included Rogers Electric Corporation and Chandler Plumbing and Heating. Figure 9 shows the project enclosed in its "cocoon," with the existing bank to the left, south on Noble Street.

PLYWOOD SUPPLY

Two views of this interesting structure have been included; Figure 10 looks generally north, while Figure 11 looks generally west. This building will be a new sales and show room facility for Plywood Supply, a dealer in lumber products and other building materials. It is located at 3504 College Road. The structural frame is built from glue-lam beams and columns, the exterior is sheathed with plywood, and the interior walls consist primarily of gypsum board. Area of this project is 17,762 square feet, and its volume approximates 213,100 cubic feet. General contractor for this project was O.L.Q. and Sons, and other contractors included Panther Electric Company and Arctic Mechanical.

SOUTH WESTGATE HOUSING

A relatively small project, but one which was active during the 1976-77 winter period, was the construction of several wood frame modular housing units in South Westgate Subdivision. Figure 12 shows one of the housing units, inside of which work progressed during the winter months. This subdivision is located south of Airport Road near Market Street.

UNIVERSITY MALL

The area's third largest project, from both an area and volume standpoint, was the construction of yet another shopping mall, located at University Avenue and Airport Road. The owner of this project is Hicel Investment Company, Inc., and the contractors included CJM Construction and Panther Electric Company. The project consisted of the expansion of an existing Safeway grocery store to a full scale shopping center containing sixteen stores. The building contains concrete floors, brick/block exterior walls, gypsum board interior walls and a suspended

ceiling. Nearly half of the new facility is devoted to a Pay'n Save store containing 39,030 square feet. The balance of the shops, plus a loft area, contain a total of 44,990 square feet, making a grand total area of 84,020 square feet. Project volume is approximately 1,227,500 cubic feet. In Figure 13, a view of the University Mall project, looking south across the parking area, is given.

WICKEN MOTEL

Like the Fairbanks Plaza Hotel, this project has been abandoned because of lack of financing. The project is located at 220 8th Avenue, approximately one half block east of Noble Street. Contractor for the project is F&H Construction Company.

PROTECTION METHODS

Eight of the building projects described in the previous section were monitored closely during the 1976-77 winter to document the methods that were used to provide temporary enclosures and temporary heating for the projects while under construction. Table II lists, in summary fashion, the results of this portion of the study.

In general, most of the buildings were fairly well "closed in" prior to the winter period, and the primary construction activities during the winter consisted of interior installation and finish work. Temporary enclosures for most projects were limited to windows, doors and larger openings in walls that were left open temporarily to allow the movement of materials and equipment. In all cases studied, the projects utilized temporary heating systems for at least a portion of the winter.

TEMPORARY ENCLOSURES

As shown in Figures 14, 15, 16 and 17, and summarized in Table II, temporary enclosures for the Bentley Mall project consisted of polyethylene-framed enclosures for windows and doors and some temporary doors of plywood panels. Figure 14 shows polyethylene sheeting draped on a large window bay surface, attached temporarily to several columns including some brick faced vertical members; a temporary plywood door is also shown on the left of this picture. Figure 15 shows another use of polyethylene, this time suspended between permanent window framing. A close up view of the exterior in Figure 15 is shown of Figure 16, while Figure 17 shows an interior view of this same surface.

Like most other projects, the permanent walls and roof for the Borough Library were constructed prior to the winter. On window areas, plywood and insulation were placed temporarily outside the windows, and the installation of windows proceeded from the interior; this protection is shown in Figure 18. Some doors were protected temporarily with plywood, while others were enclosed with polyethylene lumber frames.

Figure 19 shows the polyethylene on a temporary "garage type" door on each side of the project, as well as a temporary plywood entrance door. In Figure 20, the use of reinforced polyethylene sheeting is depicted.

The store building for Fairbanks Furniture, Inc., was probably nearest to completion of any project studied as the winter began. It had progressed to the point where permanent windows were installed. Temporary enclosures on this project were limited to the application of polyethylene sheeting on large entrance doors.

At the Fairbanks Medical Clinic, the roof and some permanent walls were constructed prior to the winter, and other wall areas were covered temporarily with polyethylene sheeting on lumber frames. Windows were also covered temporarily with polyethylene and lumber frames, and doors were enclosed temporarily with plywood sheets, as shown in Figure 21.

Most of the exterior envelope of the Federal Building project was completed prior to the 1976-77 winter. The major exception was the main entrance, located at the northeast corner of the building, which was protected temporarily with a large area of polyethylene sheeting, lumber framework, and plywood. A portion of this area is shown in Figure 22. The garage area, which will be open and unheated when the building is in operation, was covered temporarily with polyethylene sheeting to permit work to proceed inside the garage area, as shown in Figure 23. Some doors were also covered with reinforced polyethylene sheeting; the temporary garage door shown in Figure 24 is an example. A small but rather amusing example of the need to provide temporary protection is the glass-panel area of the door shown in Figure 25, which has been stuffed temporarily with fiberglass insulation!

Construction of the Interior City Branch of the First National Bank of Anchorage was the most significant example of a project whose structural frame was erected, in part, under temporary enclosures, during the 1976-77 winter. The enclosure consisted of pipe scaffolding which was covered with black, fiberglass-thread reinforced polyethylene sheeting for "walls" and "roof." Structural concrete and a portion of the exterior walls were erected within this enclosure. Later, the enclosure was removed, and the steel framework above this area was erected without benefit of temporary enclosures or heating. Figures 26, 27, and 28 give successively closer views, from different angles, of the enclosure that was erected to provide temporary protection for this project.

Windows at the Plywood Supply project were enclosed temporarily with polyethylene sheeting attached to a lumber framework. Doors were covered temporarily with plywood, as shown in Figure 29. Openings at both ends of this building were covered full-height temporarily with polyethylene sheeting and plywood panels, as shown in Figure 10. Balance of the walls and the roof had been completed prior to the winter period.

At the University Mall project, all permanent walls and roof had been constructed prior to the winter. Temporary protection was limited to the large front window area, which was enclosed with insulated plywood while work proceeded inside the building.

TEMPORARY HEATING

All projects studied utilized some form of temporary heating system during the 1976-77 winter. The study noted a definite trend toward the use of large, almost "permanent" heaters, compared to the small portable "Master" heater used in the recent past. Perhaps this trend is as much a result of the trend toward larger buildings as it is a result of the availability of more sophisticated heating equipment.

The Bentley Mall project utilized six "Powrmatic" oil-fired furnaces, each with a 450,000 BTU per hour rate. These furnaces each were rated to use four gallons per hour of number two diesel fuel. One furnace was placed in each of the four peripheral buildings, and two furnaces were placed in the large central area. In Figures 30 and 31, two of these furnaces are shown; the necessity to provide adequate ducting to the outside for combustion exhaust is illustrated in both of these figures.

At the Borough Library project, two "Armstrong" oil fired furnaces, rated at 450,000 BTU's per hour each, were utilized. These furnaces also have a fuel use of four gallons per hour of number two diesel fuel. In addition, several small "Master" heaters were utilized on occasion. Figure 32 shows a typical "Master" heater in operation, with an "Armstrong" heater in the background. Figure 33 shows an "Armstrong" furnace, vented to the outside through the insulated wall.

At the Fairbanks Furniture, Inc., store, the record shows that one "Master" heater was utilized on the first floor of this project, although details on its operation are not available.

The Fairbanks Medical Clinic project utilized two "Jackson and Church" oil-fired furnaces, each rated at 400,000 BTU's per hour and 3.6 gallons per hour of number two diesel fuel.

The large volume at the Federal Building project was heated by four large capacity heaters. These units included two "Master" heaters of one million BTU's per hour capacity each and two "Tioga" oil-fired furnaces of two million BTU's per hour capacity each. Figure 34 shows one of the two "Tioga" heaters at the Federal Building, while Figure 35 gives a detail of the ducting that carried heated air from this heater into the building. Figure 36 shows the other "Tioga" heater, which in this case was trailer mounted. It should be noted that both these units were installed outside the building, and heated air was conducted from the heaters into the building.

At the Interior City Branch Bank, three "Master" heaters, rated at 385,000 BTU's per hour, were used. The contractor estimates that these three heaters, when used to full capacity, use a total of 65 gallons of diesel fuel per hour. If this estimate is correct, this heating system consumes considerably more fuel than the other systems described herein. In addition to the "Master" heaters, one "Herman Nelson" furnace was also used on this project. Figure 37 shows one of the "Master" heaters at the Interior City Branch project.

As shown in Figure 38, the Plywood Supply project utilized one "Powrmatic" oil-fired furnace for temporary heating. Like the "Powrmatic" furnaces at the Bentley Mall project, this furnace was rated at 450,000 BTU's per hour and four gallons of number two diesel fuel.

At the University Mall project, two Jackson and Church "Flexaire" oil fired furnaces were utilized. These each have ratings of 500,000 BTU's per hour and 4.5 gallons per hour of number two diesel fuel. Several small "Master" heaters were also utilized on this project. Figure 39 shows a "Master" heater used to dry a damp corner, while Figure 40 shows a "Flexaire" heater in operation at the University Mall project. The fire extinguisher in the latter photograph also indicates the caution with which contractors approach the provision of temporary heating inside buildings under construction.

Table III gives calculated heating capacities per cubic foot for seven of the projects studied, based on the rated heating capacity of the units used and the volume of the respective project. When it is remembered that these values are capacities rather than actual usages, and when it is also realized that some projects utilize additional units for supplementary heating, the capacities in BTU's per hour per cubic foot for five of the projects appear to be quite consistent. These capacities, in BTU's per hour per cubic foot, are as follows:

Bentley Mall	-- 1.13
Fairbanks Medical Clinic	-- 1.19
Borough Library	-- 1.20
Plywood Supply	-- 2.11
University Mall	-- 0.81

The Federal Building project, at 3.23 BTU's per hour, is somewhat higher than these five; a possible explanation is that the parking areas within the structure were heated during the winter period, and these large wall areas were uninsulated and were simply draped with polyethylene sheeting. The Interior City Branch Bank capacity of 5.70 BTU's per hour per cubic foot is higher than the other figures for two reasons: 1) the "wall" and "roof" were simply uninsulated polyethylene sheets, and 2) the volume that was heated was actually larger than the 202,500 cubic foot building volume, since the enclosure was erected outside the wall and roof.

For comparison, values have been included for the Laboratory Building Addition project which was the subject of an earlier case study.¹ It is noted that the actual capacity of this steam heating system is 8.23 BTU's per hour per cubic foot, when heating capacity is based on the actual output for the day when the output was the greatest. Actual recorded average usage between 26 January and 15 April 1974 for this project was 4.79 BTU's per hour per cubic foot. These higher figures, in comparison with those in the balance of Table III, are probably due to two reasons; 1) winter conditions during the winter of 1973-74 were considerably colder than those encountered during the 1976-77 winter, and 2) large portions of the Laboratory Addition Project were uninsulated during a part of the 1973-74 winter when temporary heating was in use.

CONSTRUCTION ACTIVITIES AT VARIOUS TEMPERATURES

As stated in the project proposal, one of the objectives of the research project was to "catalog the kinds of construction activities that are carried out at various temperatures in the winter." Although weather conditions in the Fairbanks area during the 1976-77 winter varied considerably from normal, a record of various kinds of construction activities at different weather activities was maintained, and it shows that contractors are doing a variety of construction work under wintertime conditions.

WEATHER CONDITIONS, WINTER 1976-77

Weather conditions in the Fairbanks, Alaska, area in 1976-77 winter were considerably warmer and drier than normal. Figure 41 contains a graph of daily average temperatures for the winter as recorded at the Fairbanks International Airport. Comparison of the "actual" with "mean" averages indicates that on very few days was the actual temperature less than the mean for the date and that, for many days, the actual temperature was considerably in excess of the mean for the date.

Table IV contains a summary of temperature and precipitation data for the months of October 1976 to April 1977. For those seven months, a mean temperature of 12.35°F exceeded the record mean of 5.93°F by 6.42°F. Only in October, March and April was the actual mean lower than the record mean. For the three month period, December 1976 through February 1977 -- months for which the record mean is below 0°F -- the mean for the 1976-77 period was +4.71°F, a departure of +13.46°F.

January 1977 was the third warmest January in sixty years of records, the only warmer Januaries having been in 1926 and 1937 with averages of 12.6 and 11.4°F, respectively, compared to January 1977's mean of 9.8°F. The high for the month was +46°F, recorded on January 24, 1977; this maximum temperature was only 1°F below the highest January temperature ever recorded in Fairbanks. The average temperature for January 4th was 32°F, a departure of 46° from the record mean for that date. With one exception, the average temperature recorded for each day in January was higher than the record mean for the date; the exception was January 30, when the average temperature of -10°F was 1° below the record mean for the date. The lowest temperature in January was -22°F, also recorded on January 30.

Thus, temperature conditions in the winter of 1976-77 were pleasant for Fairbanksans but were not cooperative in terms of providing "typical" conditions under which to observe wintertime construction activities in the interior of Alaska.

Another measure of the mild wintertime temperatures in Fairbanks in the winter of 1976-77 is the heating degree days record. For the period 1 July 1976 to 31 March 1977, the total heating degree days, using 65°F as a base, were 10,918, which is 87% of, and a departure of 1590 degree days from, the normal of 12,502 heating degree days for the nine month period.

Fairbanks also experienced an abnormally dry winter, continuing a trend which, since 1971, has seen less than normal annual rainfall each year. The months of November, December, and January, had rainfall amounts that were 19%, 13% and 42% of normal, respectively. Total rainfall for the seven months between October 1976 and April 1977 was 2.84 inches, 69% of the normal rainfall of 4.10 inches for that seven month period. For the three month period between December 1976 and February 1977, total rainfall was 65% of normal, 1.20 inches compared with the normal of 1.84 inches.

CONSTRUCTION ACTIVITIES

Table V summarizes the various construction activities that were recorded during visits to construction project sites. Because of the abnormally high temperature conditions experienced in Fairbanks during the 1976-77 winter, the lowest outside air temperature during a site visit was only -12°F. It will be noted in Table V that site visits were conducted at temperatures up to +32°F.

From Table V, no trend of types of activities as a function of exterior temperature can be discerned. It is seen that interior work, including electrical mechanical, masonry, sheet rocking and taping, and painting, were conducted at temperatures below 0°F, as well as above 0°F. Further, it is noted that temporary heating systems maintain temperatures ranging from +43°F, at the Interior City Branch on November 20, 1976, when the exterior temperature was 7°F, to +90°F at the Bentley Mall project on November 7, 1976, when the exterior temperature was +31°F. Generally, temperatures range between the low 50's and the mid 60's, comfortable indeed for the construction craftsman who often experiences considerably lower temperatures when working outdoors.

It is of interest to note that the Interior City Branch of the First National Bank of Anchorage project erected steel "in the open," after the polyethylene sheeting had been removed. Without benefit of enclosures or heating, steel was erected at this project and roof fascia was installed on January 19, 1977, while the air temperature was -1°F, and steel erection also went forward on January 7, 1977, while the air temperature was +14°F. Also, roofing was installed on this project in the "open" while the air temperature was an estimated -2°F on January 20, 1977.

Figures 42 through 46 show a scattering of various construction activities that were conducted inside of buildings under construction while wintertime conditions prevailed. In Figure 42, a pipefitter tightens a connection at the Borough Library project while the outside temperature is -12°F. Figure 43 shows carpenters laying out a reception room at the Fairbanks Medical Clinic project while the outside temperature is +3°F, and Figure 44, taken at the Federal Building project, shows an always-important construction activity --the storage of materials -- while the exterior temperature was +12°F. In Figure 45, an ironworker installs bolts at the Interior City Branch project while the temperature is +14°F. Finally, Figure 46 shows a general view of the interior of the Plywood Supply project, kept warm to temperatures between 50° and 61°F while the outside temperature was -7°F.

INTERIOR TEMPERATURES

Another objective which the study attempted to fulfill was to record temperature variations at different locations at buildings that were enclosed and heated temporarily during wintertime construction activities. Table VI contains a record of the temperatures thus recorded, together with an indication of the location where these temperatures were taken and the exterior temperature at the time of visitation.

As was noted in the previous section, the lowest inside temperature recorded on any visit was $+43^{\circ}\text{F}$, and the highest temperature recorded was $+90^{\circ}\text{F}$. At the Borough Library project on December 30, 1976, when the exterior temperature was -12°F , the interior temperatures varied between 59°F at the center of the first floor, to 72°F , in the second floor mechanical room. This record represents a 13° temperature differential. At the Plywood Supply project on December 30, 1976, an 11° differential was noted between the first and second floors, while at the same project on January 19, 1977, a 5° differential was noted between the ground floor and second floor. At the University Mall project, which was essentially a single story project, a slight 3° difference was noted between the back wall and center on January 19, 1977, while a difference of 3° was also noted on the first floor at this project on January 6, 1977. A back room on the small second floor was recorded at 61°F , 5° higher than the lowest temperature recorded on the first floor on January 6, 1977. At the Fairbanks Medical Clinic, on January 6, 1977, a difference of 11°F was noted between the first floor hallway and the second floor by a stairwell. On January 9, 1977, the Borough Library project had interior temperatures ranging between 63° on the first floor and 69° in the second floor mechanical room.

An interesting series of temperatures was recorded inside the temporary polyethylene enclosure at the Interior City Branch on November 20, 1976. All temperatures were recorded at the south end of the east wall, at successively higher elevations. The temperatures generally increased with increasing elevation, as expected, ranging from 43°F four feet above the ground to 50°F twenty feet above the ground. This variation is interesting, as one would expect a rather larger differential.

In contrast to the University Mall record obtained on January 6, 1977, the Bentley Mall project, also a one-story shopping center, experienced wide variations in temperatures when visited on January 7, 1977. Although most of the project was maintained at a temperature approximating 68°F , temperatures ranged up to 87°F on the floor at the northwest corner and even to 90°F near a furnace. It should be noted that these temperatures were recorded when the exterior temperatures was $+31^{\circ}\text{F}$.

SUMMARY AND CONCLUSIONS

The study described in this report is really the third in a series of projects supported by CRREL for which the writer has served as principal investigator. In the first of these projects, a case study was conducted of the Laboratory Building Addition at the University of Alaska during 1973-74 winter.¹ That project reported on enclosures and heating methods used, temperatures observed, and estimated costs of providing temporary protection. The second such project developed a computer program for estimating heating requirements for buildings under construction in cold regions.² It also conducted an extensive literature search of cold weather construction projects and, further, polled Alaskan contractors to determine the kinds of activities that they undertake at various temperatures during the winter.

The present study looked at a variety of construction projects in the Fairbanks, Alaska, area during the 1976-77 winter. The process was one of observation and documentation, with no attempt made to suggest or demonstrate innovative protection methods to the contractors. It simply recorded the methods used on the projects that were underway during this winter.

Contractors do work in the winter, a fact confirmed by the study. Of the twelve building construction projects investigated, nine went forward under wintertime conditions. The remaining three were inactive, but none was inactive because of wintertime conditions. Two of the three inactive projects were suspended due to financial reasons, while the third was delayed because of a lack of sufficient design information.

Activities were limited mainly to interior installation and finish work. This fact confirmed that many contractors attempt to complete the exterior shell of their projects prior to the winter period, thus avoiding the necessity for extensive temporary enclosures. Well-managed construction work in cold regions is therefore dependent not only upon materials and techniques that provide protection against the winter environment but is especially dependent upon the manager's ability to schedule and coordinate his operations in a timely fashion, to avoid having to use such methods if possible. When necessary, however, such temporary enclosures are utilized. Also, some construction activities are conducted "in the open" without the benefit of temporary enclosures and heating.

The contractors studied in this project utilized relatively simple enclosures, consisting primarily of polyethylene sheeting, lumber framework, and plywood paneling, some with insulation attached. Contractors seem to be utilizing increasingly sophisticated heating methods, including many large heating furnaces as opposed to more traditional "Master" heaters.

Temperatures inside buildings vary, as expected, but the study found that most projects had interior temperatures that vary between 50°F and 65°F.

The 1976-77 winter in Fairbanks was far from typical! Temperature conditions were much higher than normal, while precipitation was considerably less than normal. Thus, the investigation was necessarily limited to rather "warm" temperatures, and conclusions regarding what contractors do at temperatures between -60°F and -20°F cannot be drawn from this study.

As information on temporary protection of wintertime construction becomes increasingly available, several additional pieces of data would greatly assist in "filling the gaps" for the contractor and owner engaged in construction operations in the winter. The following recommendations for further study are suggested as a result of the work carried out under the project reported herein:

1. Roof construction under wintertime conditions. The Interior City Branch Bank roof was installed at temperatures approaching 0°F, and a modest project to investigate and document the methods used and the resulting product should provide valuable information.
2. Crack infiltration around temporary window and door enclosures. There is a lack of hard data on "crack infiltration factors" for windows and doors protected temporarily while under construction. A cooperative project between the University of Alaska and CRREL should be conducted, utilizing an air leakage device and infrared photography, to determine heat loss characteristics for several types of window and door enclosures in a building under construction in Alaska in the winter.
3. Criteria for the selection of temporary heating and enclosures methods. Guidelines are needed to assist the contractor in the economical selection of methods of temporary protection. A project should draw upon the results of previous research to develop an easy-to-use handbook that would help in the selection of protection methods under various conditions.

Why work in the winter? For the contractor, he can utilize what otherwise would be idle equipment and manpower, and he can, in turn, receive income sooner than if he delayed construction work into the summer period. For the owner, his project will be available more quickly. And for the construction worker, forty hours of construction work per week is much appreciated, especially when compared to sitting at home in front of the television! A workman on one of the projects described in this report commented, "It is better than unemployment," while another said, "The work helps to pay the bills."

LITERATURE CITED

1. Bennett, F.L. (1975) Temporary enclosures and heating during construction: A case study of the laboratory building addition, University of Alaska. CRREL Special Report 223.
2. Bennett, F.L. (1977) Estimating heating requirements for buildings under construction in cold regions: An interactive computer approach. CRREL Special Report 77-3.

Table I. Construction project information.

PROJECT NAME	LOCATION	OWNER	CONTRACTOR(S)	JOB SUPERINTENDENT	PROJECT DESCRIPTION	PROJECT DIMENSIONS
Bentley Hall	32 College Road	Barsa Development Co.	Strand, Inc. (General), Panther Electric Co. (Electrical), M. R. Gracie Co. (Electrical), Arctic Mechanical (Mechanical)	John Compton	Thirty-two unit shopping mall. Brick faced exterior. Extensive glass windows & doors. Wide pedestrian aisle-ways. Small shops.	Main building 17 shops-50,000 sq. ft. Outside buildings 6 shops-10,000 sq. ft. Safeway 7 shops-10,000 sq. ft. Pay 'N Save 30,000 sq. ft. Total 100,000 sq. ft. Volume = Approx. 2,400,000 c.f.
Borough Library	Airport Road & Conley Street	Fairbanks North Star Borough	Modern Construction, Inc.	John Hoenesmaker	New library. Concrete structure. Brick faced exterior. Concrete floors. Building paper, glass insulation & clear heart cedar exterior.	Area = Approx. 50,000 s. f. Volume = Approx. 750,000 c.f.
Fairbanks Furniture, Inc.	College Road & Illinois Street	William Stewart	William Stewart		Two stories plus basement; concrete block exterior. (Project activities suspended due to financing difficulties)	Area = Approx. 20,000 s. f. Volume = Approx. 231,700 c.f.
Fairbanks Plaza Hotel	First Avenue & Hall Street	Fairbanks Real Estate Development Corp. & Fairbanks Development Corp.	O.L.Q. & Sons (General), Life Systems Corp. (Mechanical & Electrical)		Addition to existing medical clinic. Two floors of small offices & waiting rooms. Large footage of interior walls. Metal ceiling. Plywood sheathing. Concrete ground slab.	Approx. 125' x 180' two stories Area = Approx. 45,000 s. f. Volume = Approx. 675,000 c.f.
Fairbanks Medical Clinic	19th Avenue & Conley Street	Fairbanks Medical & Dental Arts Clinic	Non-Mac Builders	Gerald Lizotte	Office building for federal government. Brick faced exterior. (4th floor); minor pool deck; garage facilities. Steel frame; metal sheathing on exterior walls.	Overall 190' x 280' Area = 10,000 s. f. (including parking area) Volume = 1,015,000 c.f. (office area) Approx. 1,855,000 c.f. (Total)
Federal Building	Airport Road & At Steese Highway	U. S. Government General Services Administration	Huffman Construction Company (General) Western Mechanical, Inc. (Mechanical) Peter Kiewit Sons (Temp. Heating)		(Project activities suspended during winter, due to design delays)	Area = 78971 s. f. Volume = Approx. 1,025,800 c.f.
Highway Bridge	Chena River at Steese Highway	State of Alaska Department of Highways	Peter Kiewit Sons Company	Jim Carlson	Bank addition and remodeling. Steel frame; brick exterior; concrete floors.	90' x 75' (2 stories) Area = 13,500 s. f. Volume = 202,500 c.f.
Hospital Addition	19th Avenue & Lathrop Street	Fairbanks Memorial Hospital Assoc.	Tate & Co. (General), Rogers Electric Corp. (Electrical), Chandler Plumbing & Heating (Mechanical)	Frank Lucas	New sales & showroom facility for lumber products and building materials. Glulam structure; plywood sheathed exterior walls; gypsum board interior walls.	165' x 65' (first floor) 165' x 41' (second floor) Area = 17,752 s. f. Volume = Approx. 213,100 c.f.
Interior City Branch	8th Avenue & Noble Street	First National Bank of Anchorage	O.L.Q. & Sons (General), Panther Electric Co. (Electrical), Arctic Mechanical (Mechanical)	Joe Coty	Wood frame modular housing units.	Pay 'N Save 228' x 164' = 39,030 s. f. Balance of Shops 190' x 183' + 55' x 40' = 38,430 s. f. Office building 164' x 40' = 6,560 s. f. Total Area = 144' x 40' = 58,020 s. f. Volume = 1,227,500 c.f.
Plywood Supply	3504 College Road	Plywood Supply			Expansion of existing Safeway grocery store to a shopping center with sixteen units. Brick faced exterior. Gypsum board interior walls, suspended ceilings.	(39,030 and 38,430 are 15' story height) (6,560 is 10' story height)
South Westgate Housing	Westgate Subdivision Near Airport Road			Tom Murphy	(Project activities suspended due to financing difficulties)	
University Hall	University Avenue & Airport Road	Hickel Investment Co., Inc.	C. J. W. Construction (General) Panther Electric Co. (Electrical)			
Wicken Hotel	220 Eighth Avenue	Linda Wicken	F & H Construction Co.			

Table II. Temporary protection methods.

PROJECT	TEMPORARY ENCLOSURES	TEMPORARY HEATING
Bentley Mall	Polyethylene-frame enclosures for windows and doors. Some plywood doors. (Permanent walls and roof were constructed prior to winter period).	Six (6) "Powmatic" oil-fired furnaces. 450,000 BTU/hr. 4 gal/hr. of #2 diesel fuel. One furnace in each of four buildings; two furnaces in central area.
Borough Library	Plywood and polyethylene-frame doors. Plywood and insulation on windows during window installation. Polyethylene sheeting on lumber frame at main (southwest) entrance. (Permanent walls and roof were constructed prior to winter period).	Two (2) "Armstrong" oil-fired furnaces. 450,000 BTU/hr. 4 gal/hr. of #2 diesel fuel. Several small "Master" heaters.
Fairbanks Furniture, Inc., Store	Polyethylene sheeting on large entrance doors. (Permanent walls, roof and windows were constructed prior to winter period).	One (1) "Master" heater on first floor.
Fairbanks Medical Clinic	Plywood doors. Polyethylene-frame windows. Some polyethylene on lumber frame for wall enclosures. (Portions of permanent walls and roof were constructed prior to winter period).	Two (2) "Jackson and Church" oil-fired furnaces. 400,000 BTU/hr. 3.6 gal/hr. of #2 diesel fuel.
Federal Building	All permanent including most doors and windows, except for main entrance at northeast corner, which was polyethylene frame and plywood. Garage area covered with polyethylene sheeting. Some doors covered with reinforced polyethylene sheeting.	Two (2) "Master" heaters (1,000,000 BTU/hr.) Two (2) "Tioga" oil-fired furnaces (2,000,000 BTU/hr.)
Interior City Branch	Pipe scaffolding covered with black, fiberglass-thread reinforced polyethylene sheeting. Exterior walls were then erected within this enclosure. Steel (above) was erected after enclosure was removed.	Three (3) "Master" Heaters (385,000 BTU/hr.) (65 gal diesel fuel/hr. total) One (1) "Herman Nelson" furnace
Plywood Supply	Windows of polyethylene-lumber frame. Plywood doors. Openings at both ends covered full-height with polyethylene sheeting and plywood panels. (Balance of walls & roof were completed prior to winter period.)	One (1) "Powmatic" oil-fired furnace. 450,000 BTU/hr. 4 gal/hour of #2 diesel fuel.
University Mall	Front window portion enclosed with insulated plywood. (Permanent walls and roof were constructed prior to winter period.)	Two (2) Jackson and Church "Flexaire" oil-fired furnaces. 500,000 BTU/hr. 4.5 gal/hour of #2 diesel fuel. Several small "Master" heaters.

Table III. Heating capacities per cubic foot.

PROJECT	HEATING CAPACITY, BTU/HR	VOLUME, C.F.	BTU/HR/C.F.
Bentley Mall	2,700,000	2,400,000	1.13
Borough Library	900,000	750,000	1.20
Fairbanks Medical Clinic	800,000	675,000	1.19
Federal Building	6,000,000	1,855,000	3.23
Interior City Branch	1,555,000	202,500 ⁽¹⁾	5.70
Plywood Supply	450,000	213,100	2.11
University Mall	1,000,000	1,227,500	0.81
Laboratory Building Addition (2)	1,110,000 ⁽³⁾	134,800	8.23
Laboratory Building Addition (2)			4.79 ⁽⁴⁾

1. The volume heated was greater than this, since the enclosure was erected outside the walls.
2. Winter of 1973-74.
3. Calculated capacity of steam heating system, based on maximum daily use.
4. Actual average usage, 26 January to 15 April 1974.

Table IV. Temperature and precipitation summary.

TEMPERATURES				PRECIPITATION		
Month	Mean from Record	1976/77 Mean	Departure	Mean from Record	1976/77 Total	Departure
October	25.7	23.9	-1.8	0.84	0.89	+.05
November	2.9	15.9	+13.0	0.69	0.13	-.56
December	-9.4	-3.9	+5.5	0.63	0.08	-.55
January	-12.4	9.8	+22.2	0.74	0.31	-.43
February	-4.0	8.6	+12.6	0.47	0.81	+.34
March	8.6	4.6	-4.0	0.45	0.26	-.19
April	29.8	27.8	-2.0	0.28	0.36	+.08
Seven Months	Mean = 5.93	Mean = 12.35	+6.42	Total = 4.10	Total = 2.84 (69% of normal)	-1.26
December, Jan. February	Mean = -8.75	Mean = 4.71	+13.46	Total = 1.84	Total = 1.20 (65% of normal)	-0.64

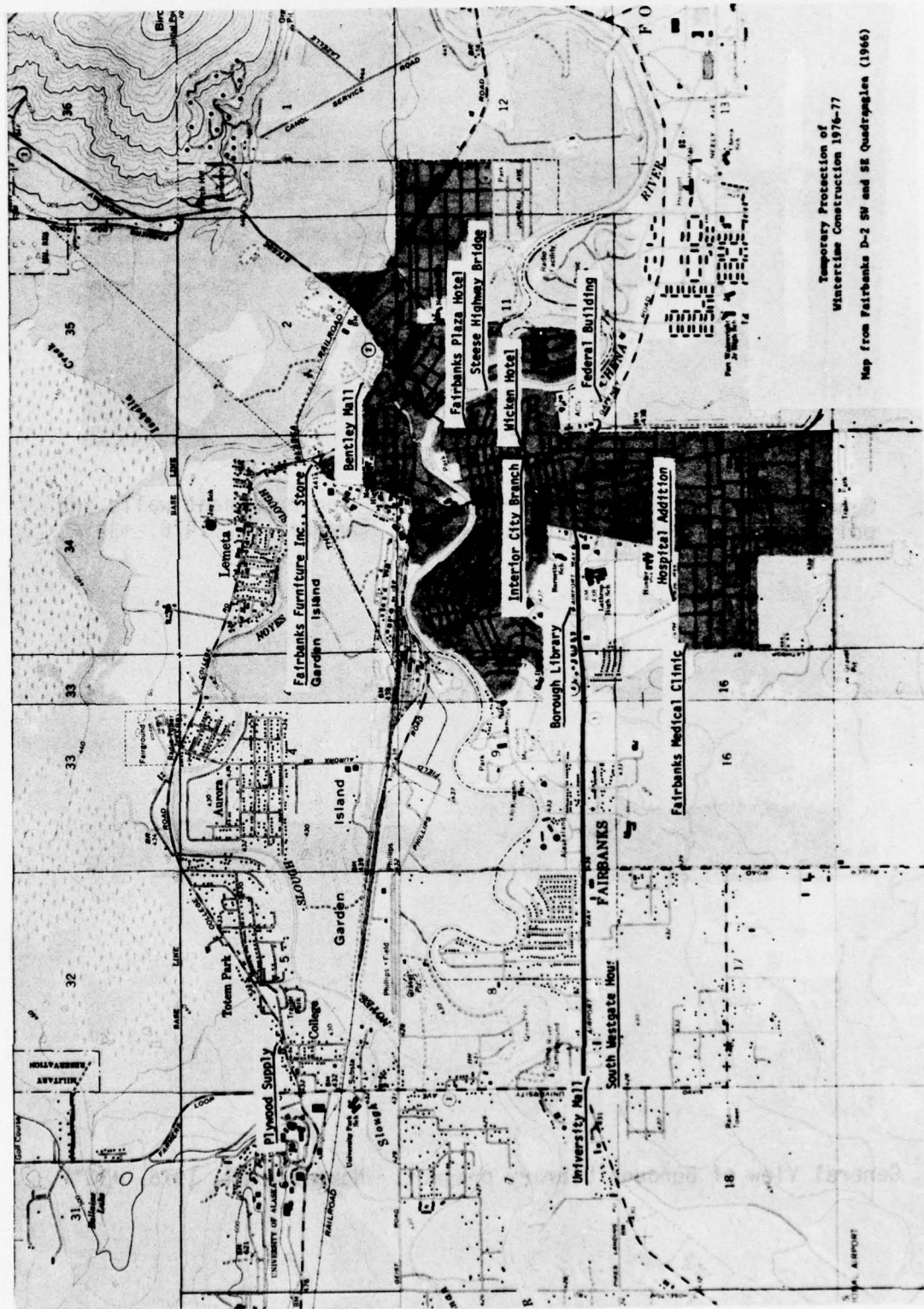
Table V. Activities vs temperatures.

EXTERIOR TEMPERATURE, °F	ACTIVITIES	INTERIOR TEMPERATURE, °F*	PROJECT/DATE
-12°	Interior electrical, plumbing, masonry. Material moving	Min: 59° (first floor center) Max: 72° (second floor)	Borough Library 12/30/76
-7°	Interior sheetrock & taping. Exterior electric power installation.	Min: 50° (ground floor) Max: 61° (second floor)	Plywood Supply 12/30/76
-2°	Mechanical ductwork, painting, concrete formwork.	Min: 58° (back wall) Max: 51° (center)	University Mall 1/19/77
-2°	Sprinkler system installation, mechanical ductwork, window frame assembly, painting.	Min: 59° (ground floor) Max: 64° (second floor)	Plywood Supply 1/19/77
-2° (est)	Roofing (no enclosures or heating)	--	Interior City Branch 1/20/77
-1°	Steel erection, roof fascia installation (no enclosures or heating)	--	Interior City Branch 1/19/77
+3°	Stair & wall construction, piping installation. Material Moving	Min: 53° (first floor center 4' above floor) Max: 64° (second floor by stairwell)	Fairbanks Medical Clinic 1/6/77
+4°	Installing ceiling, plastering, taping, sheetrock, drilling penetrations in concrete floor, cleanup.	Min: 56° (first floor at floor adjacent to exterior wall) Max: 61° (second floor back)	University Mall 1/6/77
+5°	Interior electrical, mechanical, heating controls; wall & ceiling framing; sheet rock installation; window and overhead door installation.	Min: 63° (first floor, 150' from furnace) Max: 69° (second floor, mechanical room)	Borough Library 1/19/77
+7°	Bricklaying, concrete finishing (sand, cement, and equipment stored inside enclosure)	Min: 43° (beside east wall 4' above ground) Max: 66° (beside west wall 5' above ground)	Interior City Branch 11/20/76
+8°	Interior finish work	--	Federal Building 1/7/77
+10°	Interior electrical & plumbing, wall sheathing	--	Interior City Branch 3/24/77
+12°	Installing walls, floor covering & equipment	--	Bentley Mall 3/24/77
+12°	Interior electrical & carpentry	--	Plywood Supply 11/24/76
+14°	Interior carpentry & plumbing	--	South Westgate Housing 11/25/76
+14°	Steel erection (no enclosures or heating)	--	Interior City Branch 1/7/77
+15°	Interior electrical, plastering taping sheetrock	--	Plywood Supply 3/24/77
+17°	Trim, shelving & equipment installation, painting, cleanup	--	University Mall 3/24/77
+31°	Heating system ductwork installation; plastering; installing sheetrock, wall panels, floor covering and equipment; painting	Min: 68° (most of project) Max: 90° (near furnace)	Bentley Mall 1/7/77
+32°	Interior plumbing, electrical, mechanical & carpentry; concrete placement & finishing	--	Federal Building 11/28/76
+32°	Interior electrical & carpentry	--	Bentley Mall 11/28/76
+32°	Interior electrical & floor	--	Fairbanks Furniture, Inc., Store 11/28/76

*Min/Max are Minimum and Maximum temperatures recorded during visit.
For more complete record, see Table VI.

Table VI. Interior temperature record.

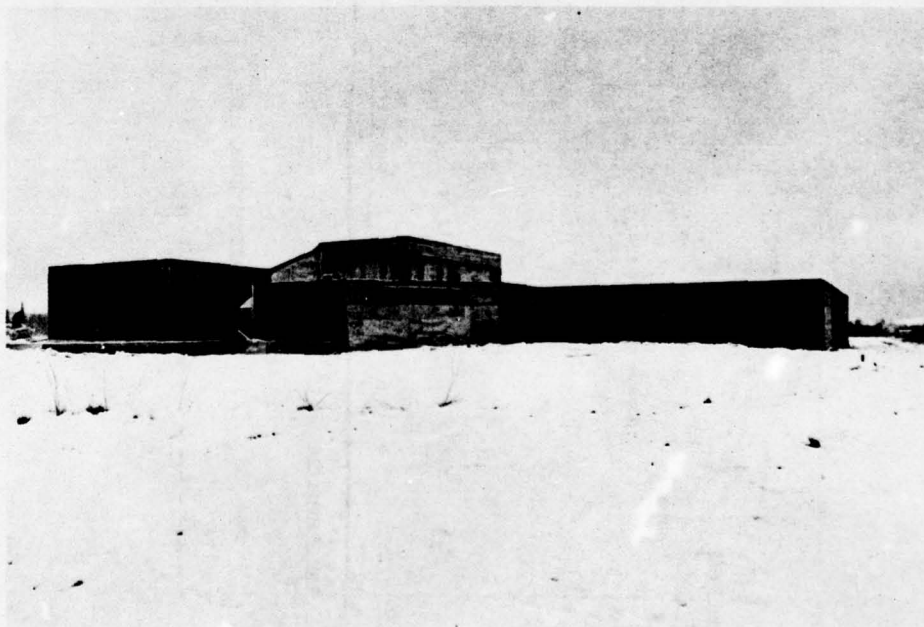
PROJECT	DATE	EXTERIOR TEMPERATURE	INTERIOR TEMPERATURE	LOCATION
Borough Library	12/30/76	-12°	59°	First floor center-far from furnace
			66°	Southwest corner-by large polyethylene covered door.
			68°	First floor-by furnace
			70°	First floor theatre-by furnace
			72°	Second floor mechanical room
Plywood Supply	12/30/76	-7°	50°	Ground floor
University Mall	1/19/77	-2°	61°	Second floor by workmen
			58°	Back Wall
			59°	Rear Mechanical Room
Plywood Supply	1/19/77	-2°	61°	Center
			59°	Blueprint desk-ground floor
Fairbanks Medical Clinic	1/6/77	+3°	64°	Second floor by carpenters
			53°	35' inside door in main hallway, first floor, 4' above floor
			57°	60' from open doorway on second floor
			62°	By wall in furnace room
University Mall	1/6/77	+4°	64°	Second floor by stairwell
			56°	First floor at floor, adjacent to exterior wall
			57°	Back Room on floor
			58°	Center of large hall, on floor
			59°	Side room near unused furnace
			61°	Second floor, back room
Borough Library	1/9/77	+5°	63°	First floor, 150' from furnace
			65°	First floor by entrance
			69°	Second floor mechanical room
Interior City Branch	11/20/76	+7°	43°	South end of east wall 4' above ground
			44°	South end of east wall, 10' above ground
			46°	South end of east wall, 7' above ground
			48°	South end of east wall, 15' above ground
			50°	South end of east wall, 20' above ground
Bentley Mall	1/7/77	+31°	68°	Throughout most of project
			75°	Center of front building
			78°	Opposite side of building from furnace
			87°	On floor at northwest corner
			90°	Near furnace



1. Construction Site Location Map



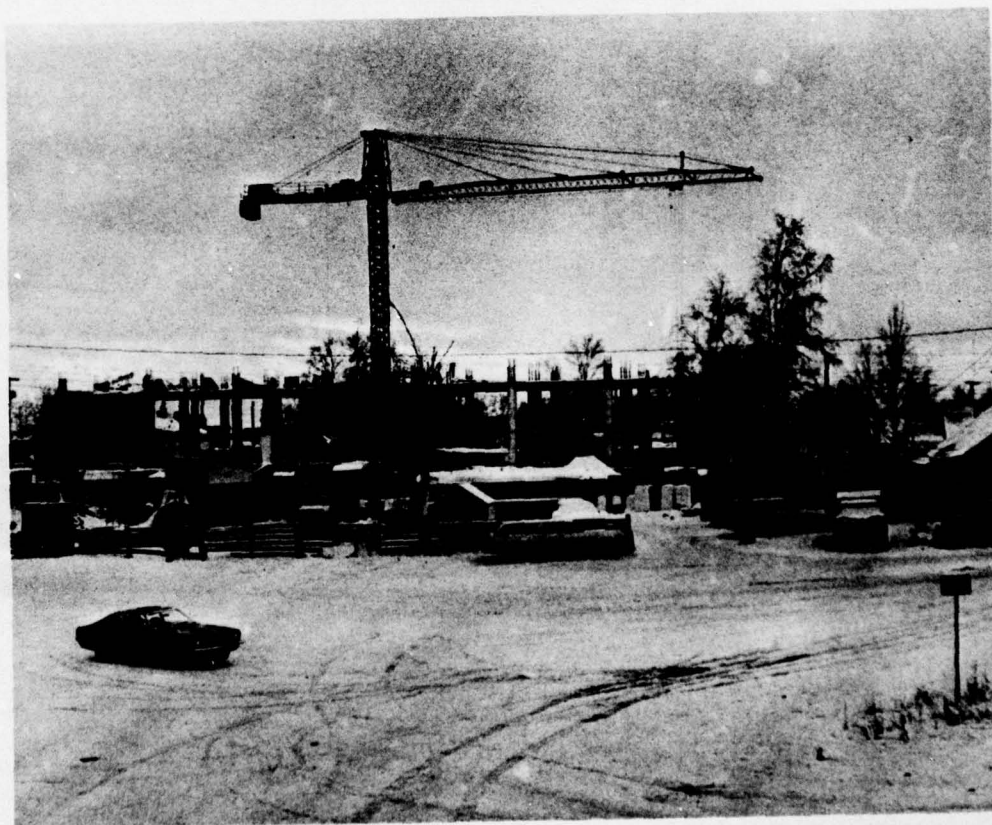
2. General View of Bentley Mall project showing permanent walls and polyethylene sheltered entrance ways. November 28, 1976. +32°F.



3. General View of Borough Library project. November 28, 1976. +32°F.



4. General View of Fairbanks Medical and Dental Arts Clinic. November 25, 1976. +14°F.



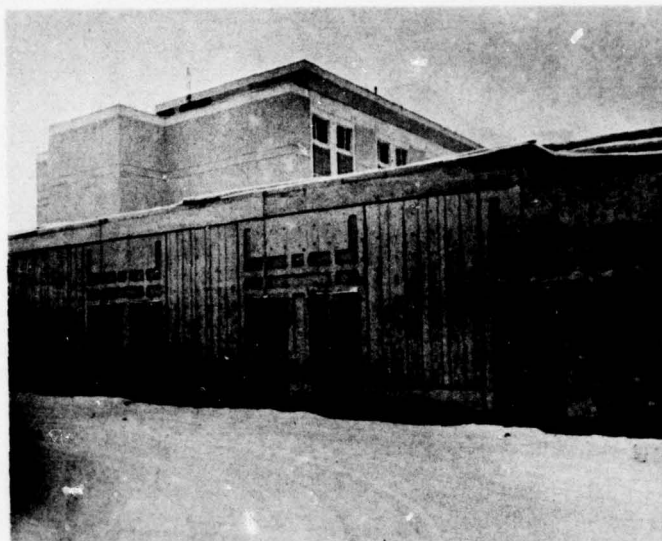
5. Fairbanks Plaza Hotel, activities suspended -- not by winter, but by lack of funds. November 28, 1976. +32°F.



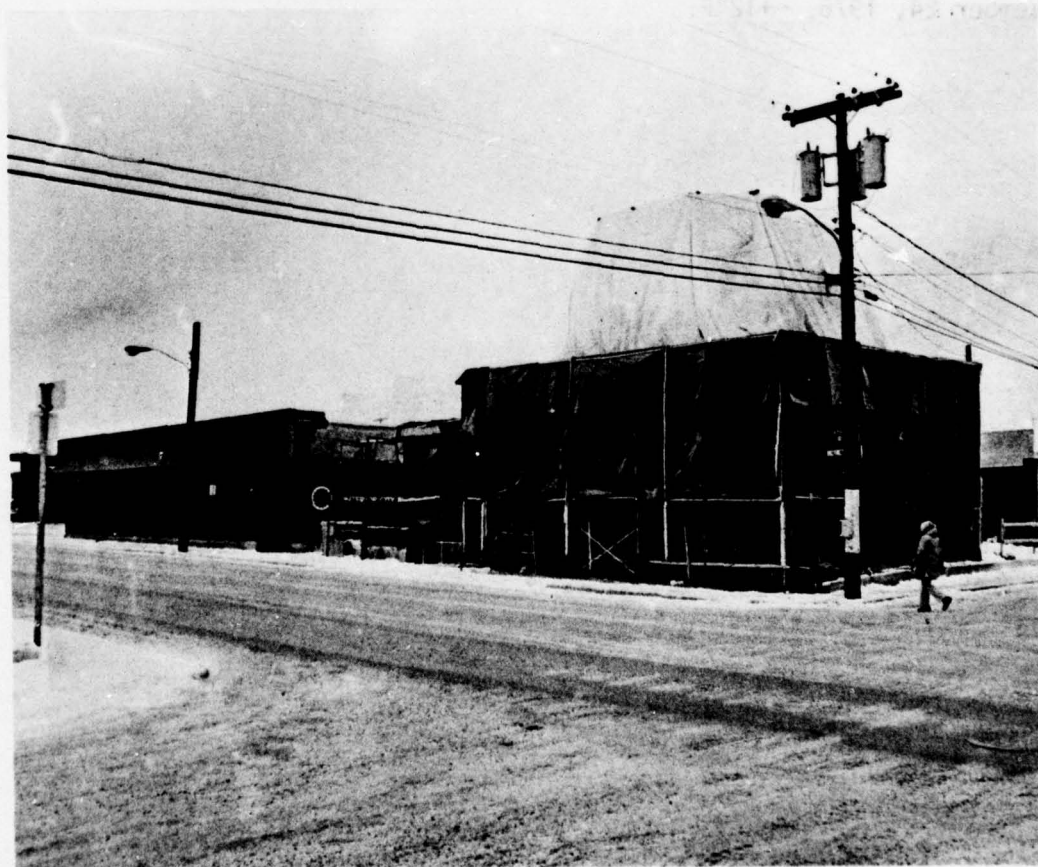
6. General View of Northeast corner of Federal Building. November 28, 1976. 32°F.



7. Steese Highway Bridge over Chena River, activities suspended over winter. November 28, 1976. 32°F.



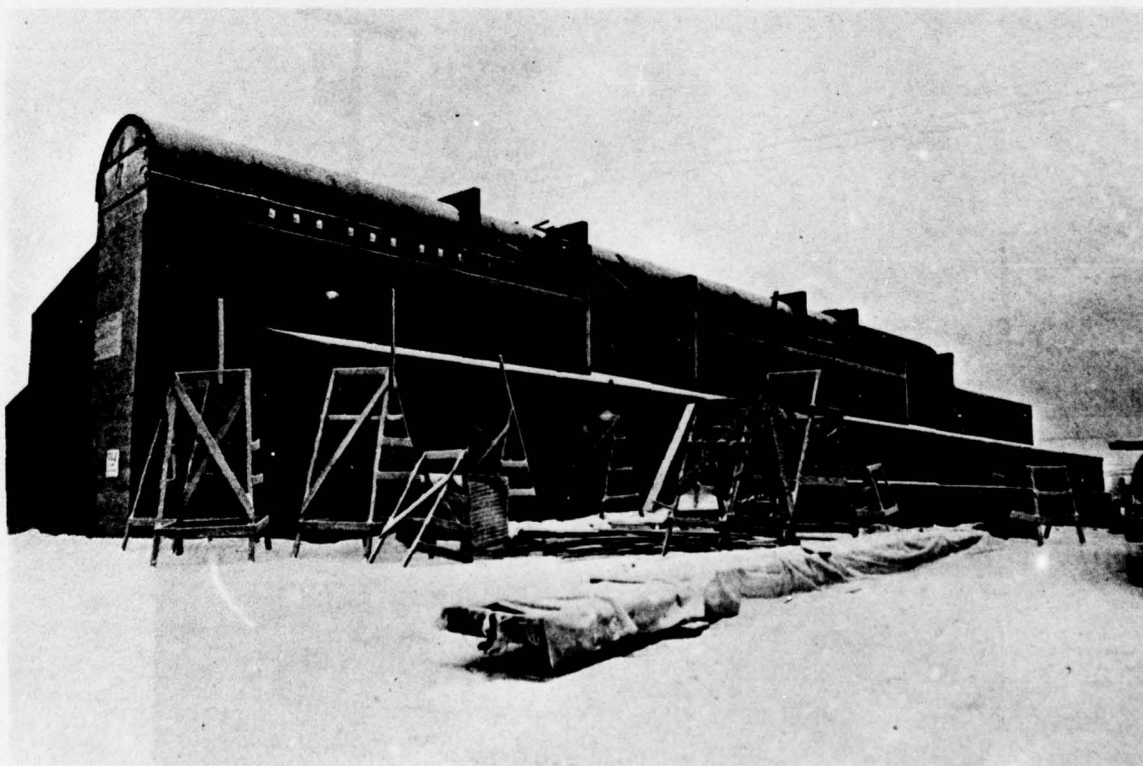
8. Fairbanks Memorial Hospital project lying inactive during winter period. November 25, 1976. +14°F.



9. General view of addition to Interior City Branch, First National Bank of Anchorage, November 28, 1976, +32°F.



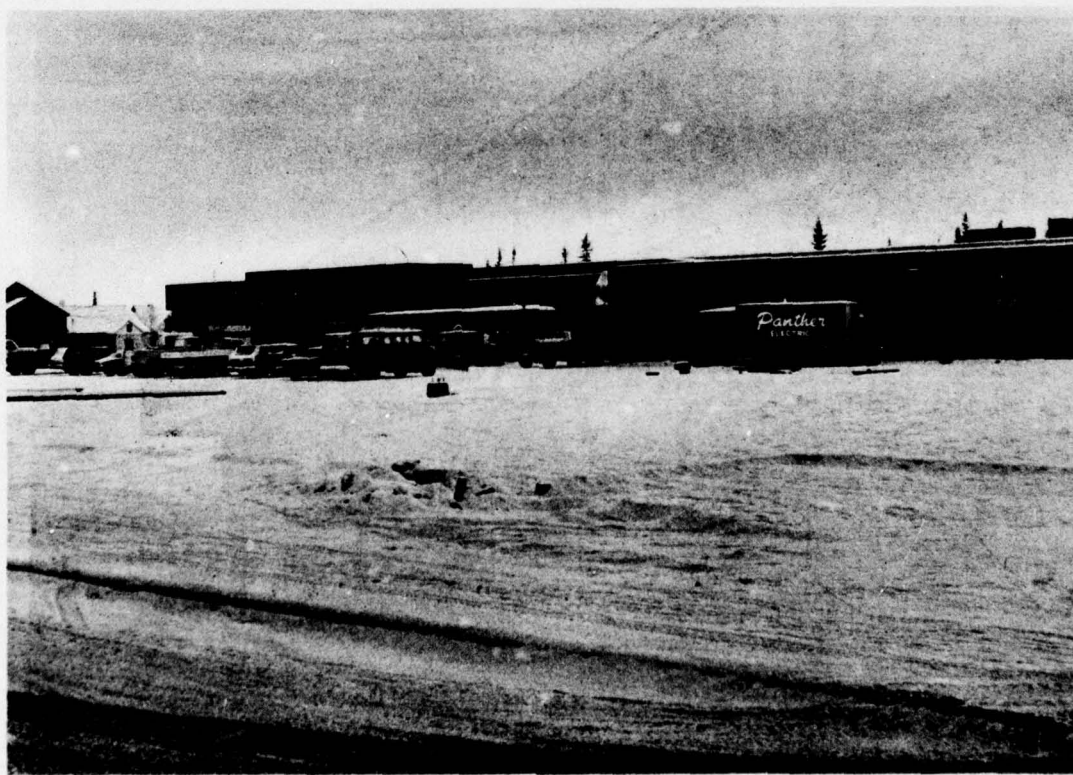
10. General view of Plywood Supply project, looking generally north.
November 24, 1976. +12°F.



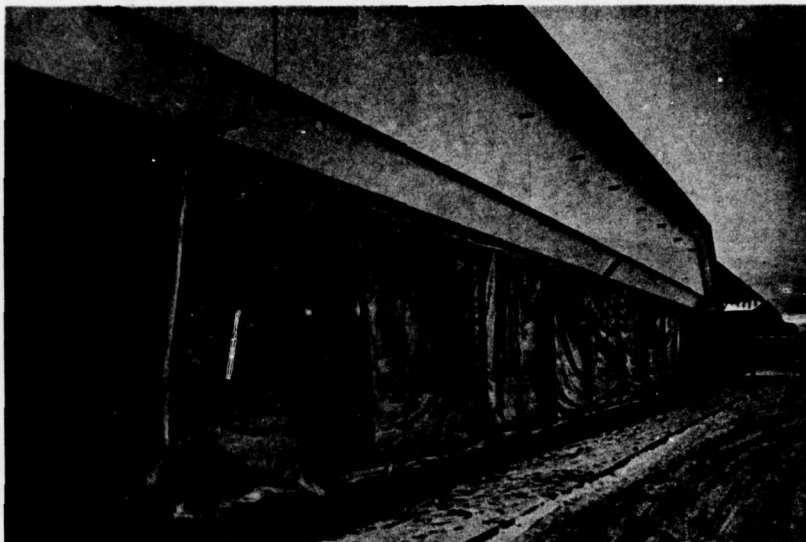
11. General view of Plywood Supply project, looking generally west.
November 24, 1976. +12°F.



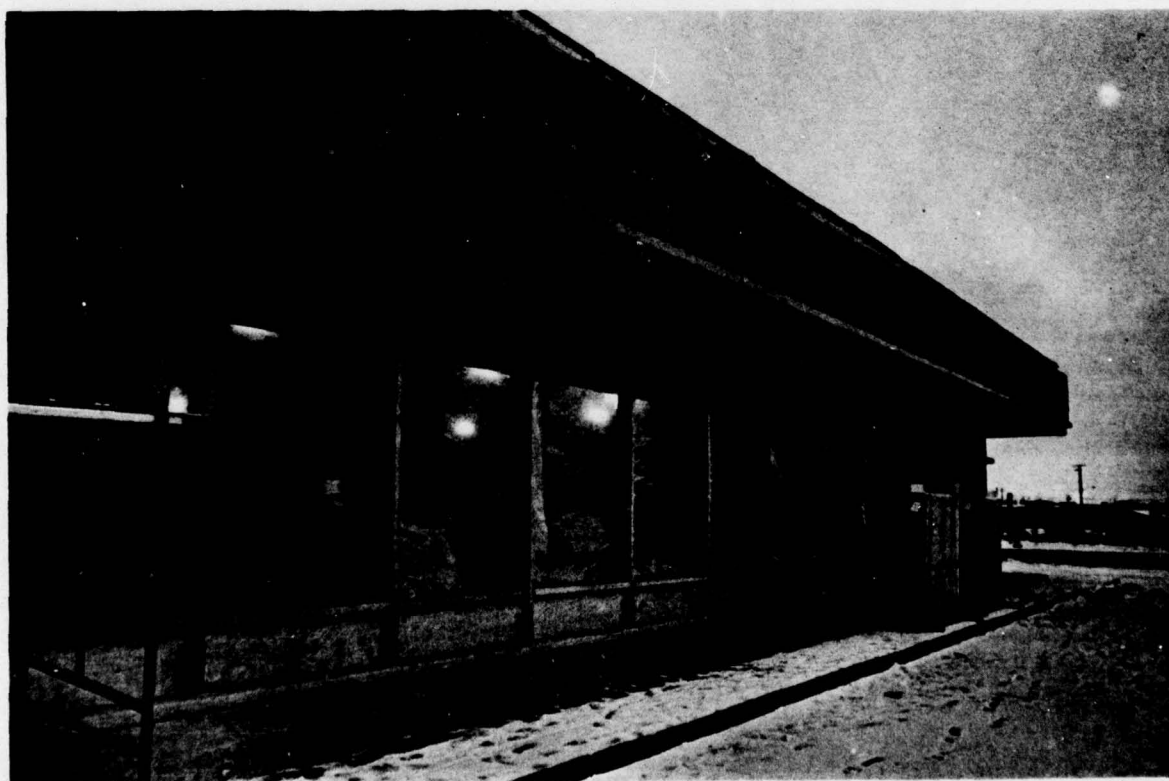
12. General view of one unit in South Westgate Modular Housing project. with work continuing inside. November 25, 1976. +14°F.



13. General view of University Mall Shopping Center project looking generally south. January 6, 1977. +4°F.



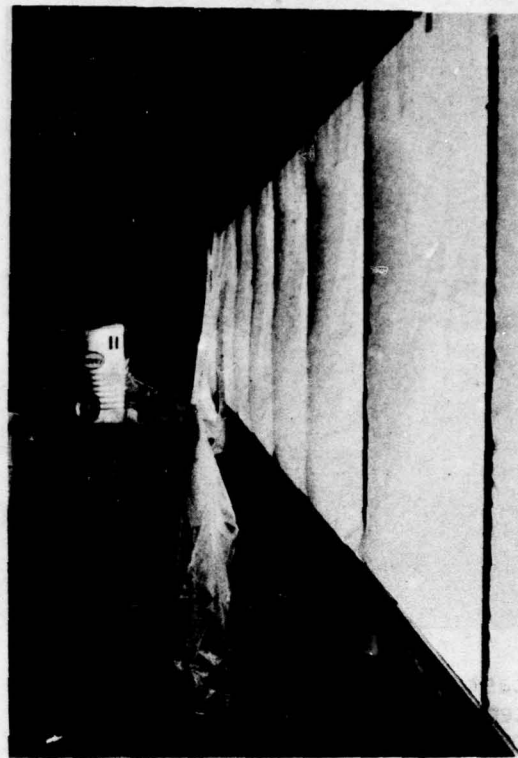
14. Polyethylene window bays at Bentley Mall project. November 28, 1976. +32°F.



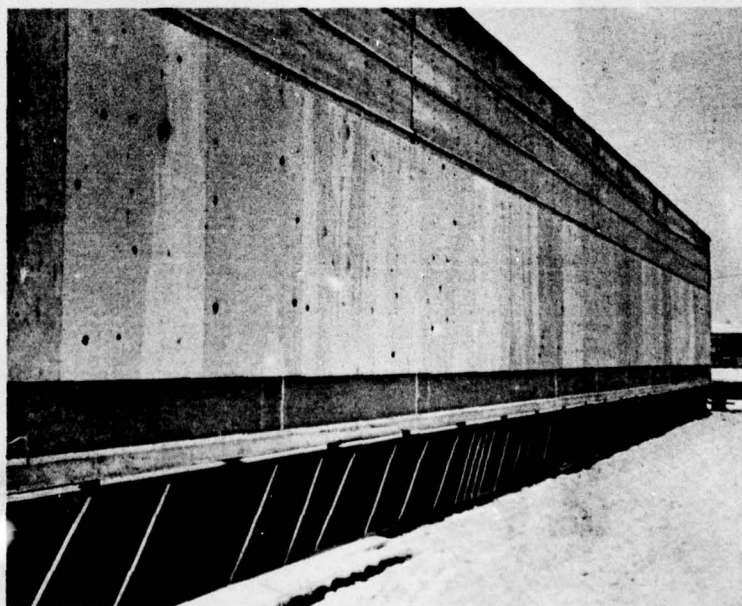
15. Temporary enclosures were window openings, Bentley Mall project. November 28, 1976. +32°F.



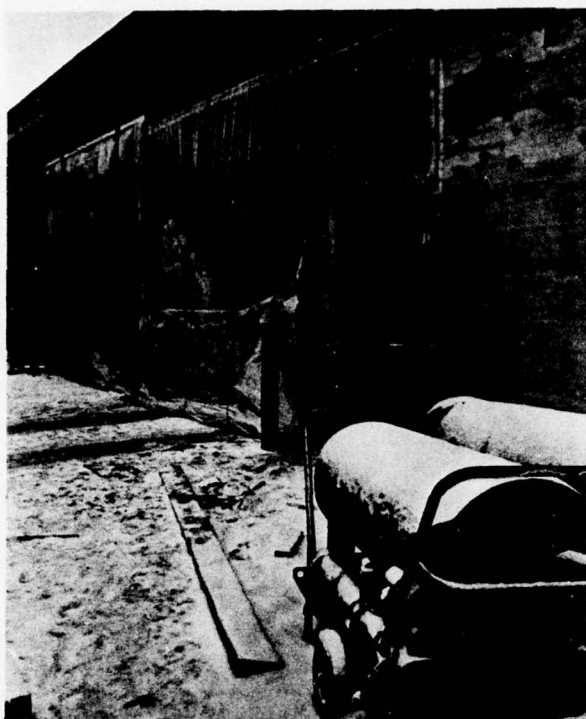
16. Close-up of temporary window coverings, Bentley Mall project. November 28, 1976. +32°F.



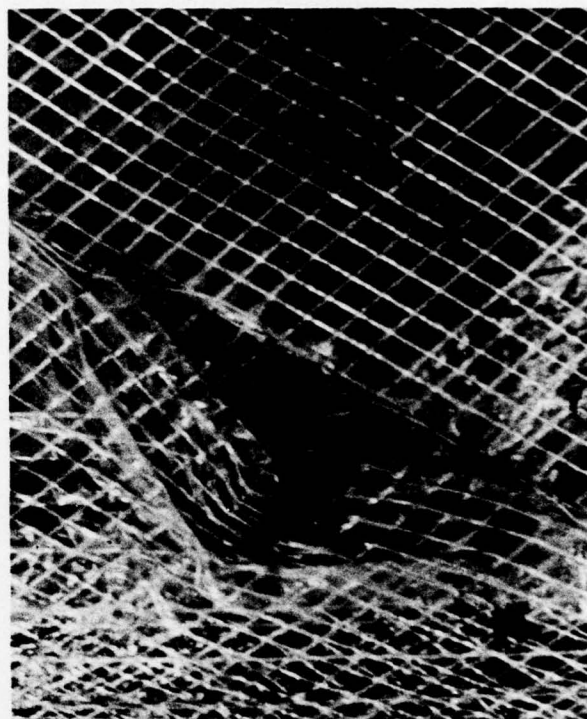
17. Temporary window enclosures at Bentley Mall project, inside view. January 7, 1977. +31°F.



18. North wall, Borough Library project, plywood sheathing protecting window placement activity. November 28, 1976. +32°F.



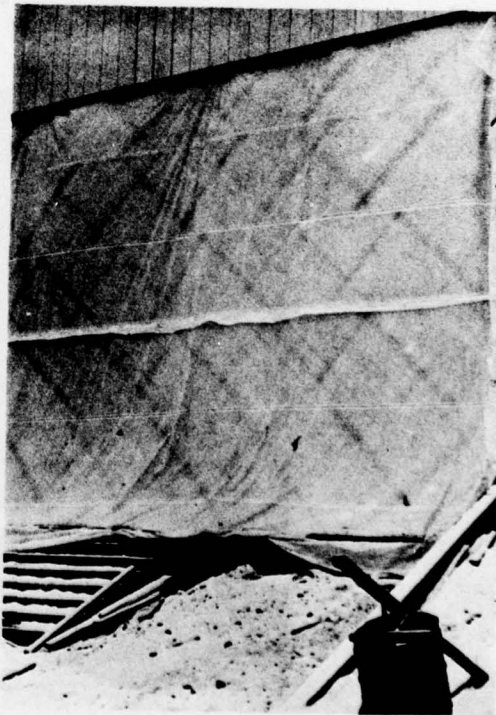
19. East side, Borough Library project, temporary garage door sheltering equipment. November 28, 1976. +32°F.



20. Reinforced polyethylene sheathing at Borough Library project. December 30, 1976. -12°F.



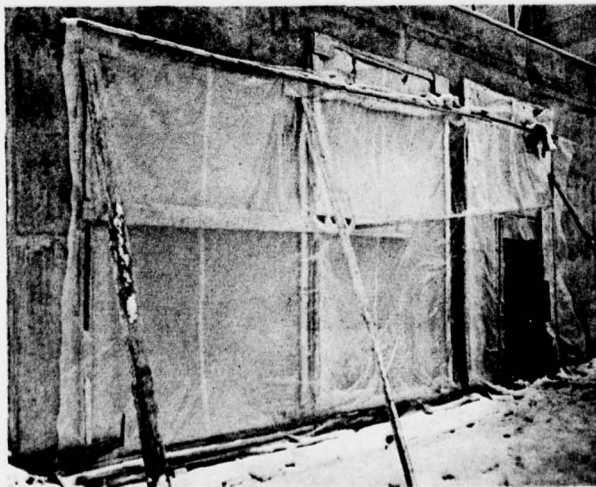
21. Plywood doors and temporary loading dock, Fairbanks Medical and Dental Arts Clinic. January 6, 1977. +3°F.



22. Federal Building project. Polyethylene cover on northeast corner. November 28, 1976. +32°F.



23. Polyethylene cover protecting parking area on southwest corner, Federal Building project. November 28, 1976. +32°F.



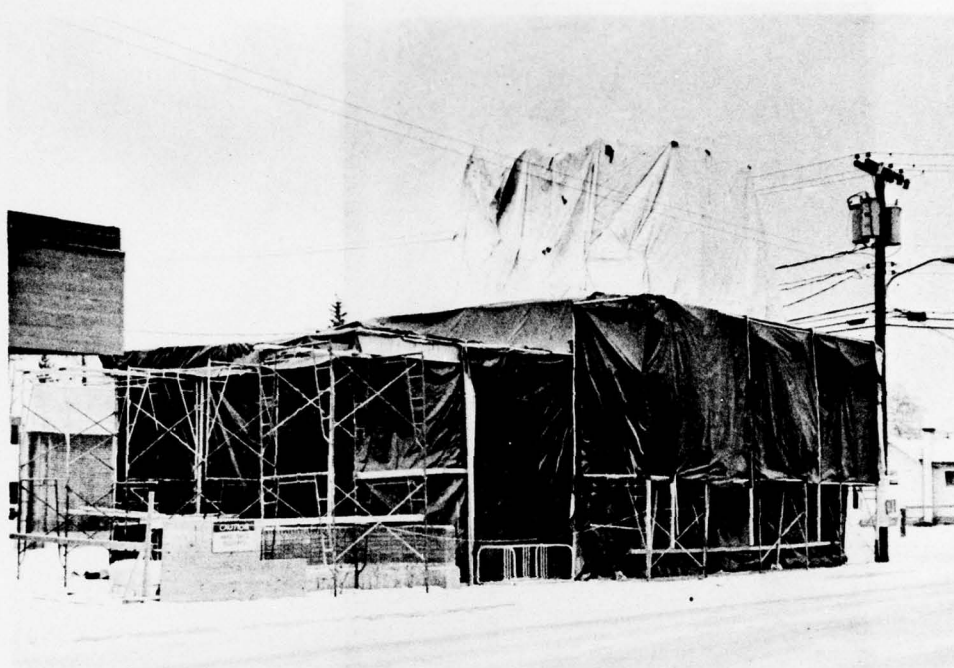
24. Reinforced polyethylene sheathing providing temporary enclosure for garage door at Federal Building project. November 24, 1976. +12°F.



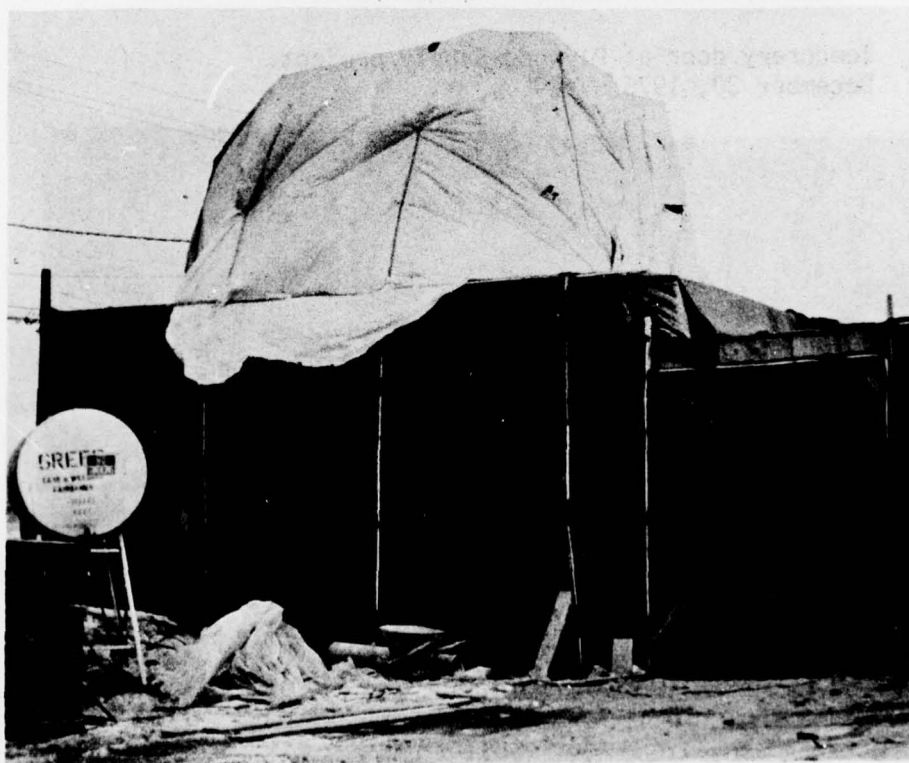
25. Partially installed door protected with insulation, Federal Building project. November 24, 1976. +12°F.



26. South and west walls of Interior City Branch project. November 28, 1976. +32°F.



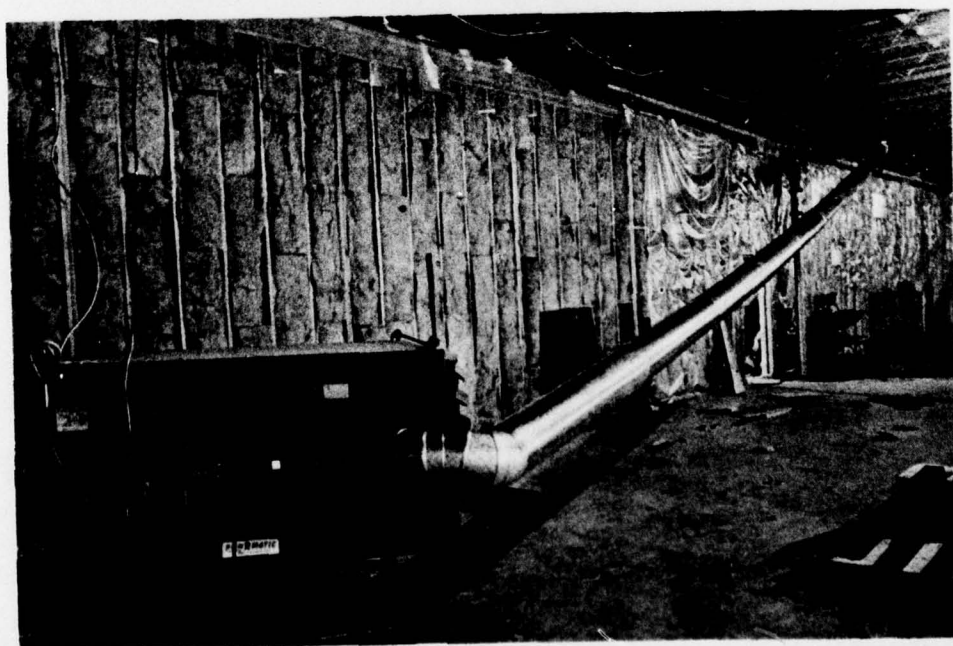
27. South and east walls of Interior City Branch project. November 28, 1976. +32°F.



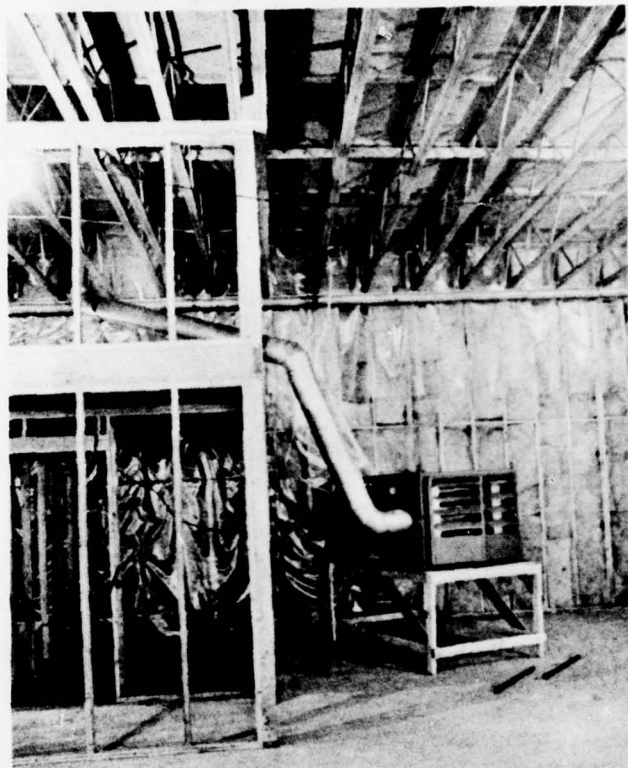
28. Close-up of west wall of Interior City Branch. November 20, 1976. +7°F.



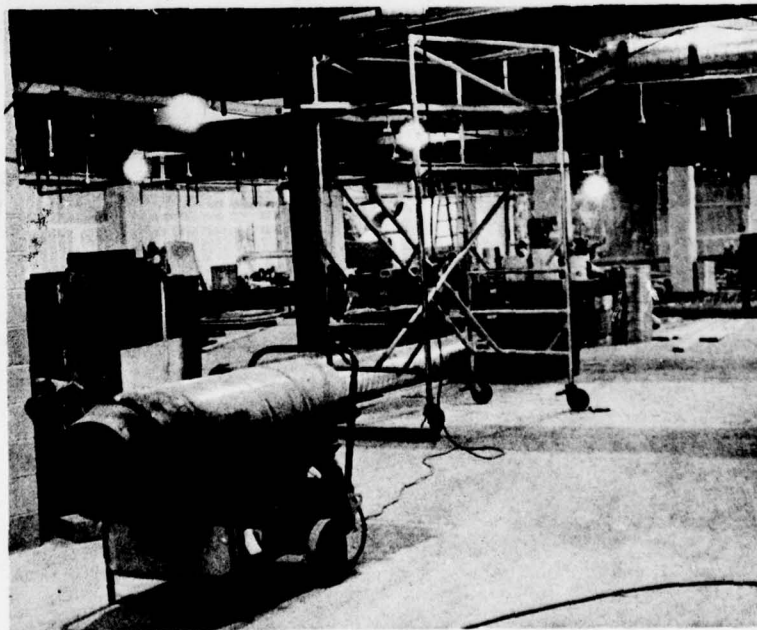
29. Temporary door at Plywood Supply project.
December 30, 1976. -70°F.



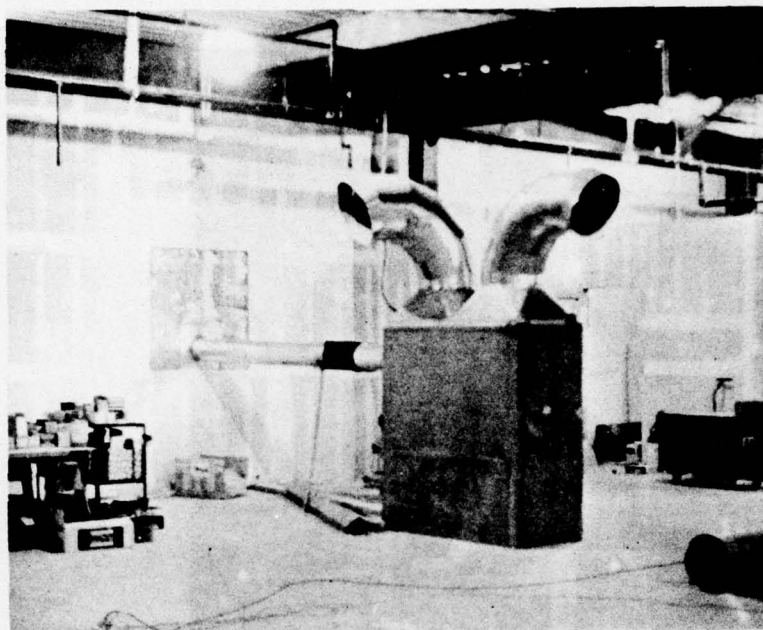
30. "Powrmatic" 450,000 BTU furnace at Bentley Mall project. November 28,
1976. +32°F.



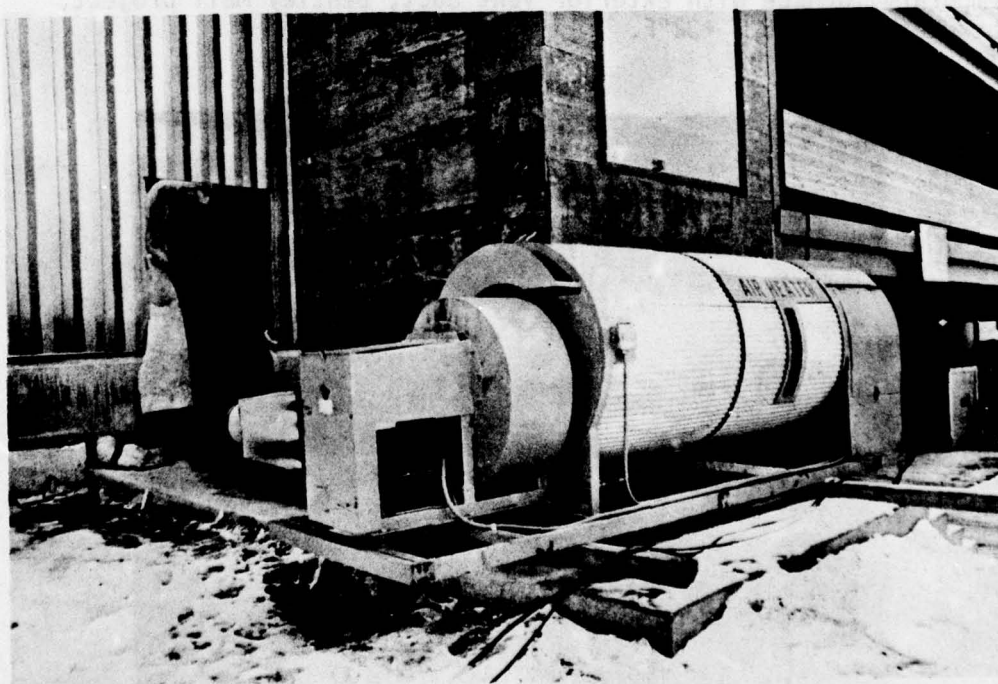
31. Temporary furnace with exterior vent duct, Bentley Mall project. November 28, 1976. +32°F.



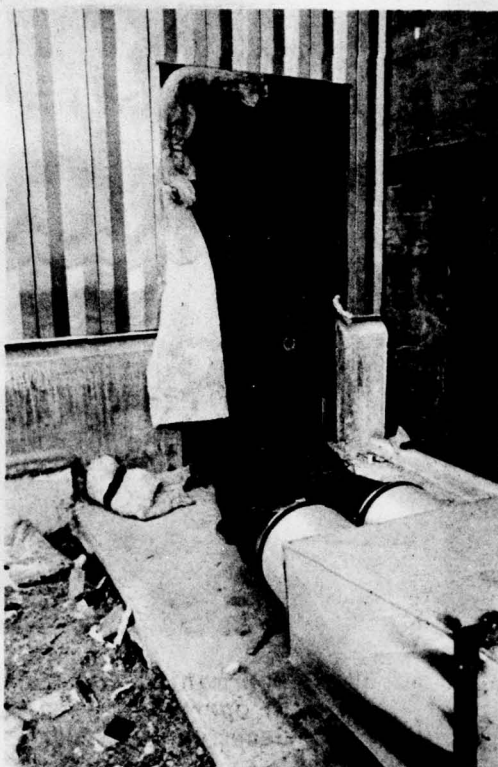
32. "Master" heater, foreground and "Armstrong" furnace, background, at Borough Library project. December 30, 1976. -12°F.



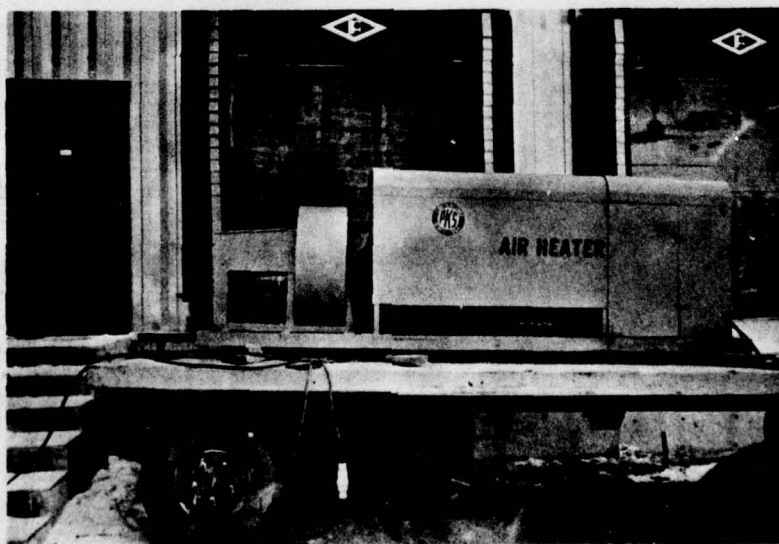
33. "Armstrong" furnace (450,000 BTU per hour) at Borough Library project.
November 30, 1976. -12°F .



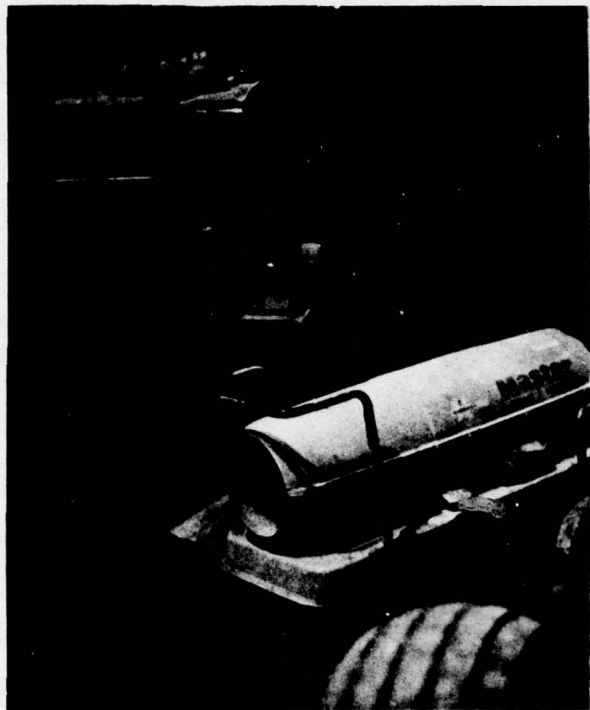
34. 2 million BTU per hour "Tioga" furnace at Federal Building project.
November 24, 1976. $+12^{\circ}\text{F}$.



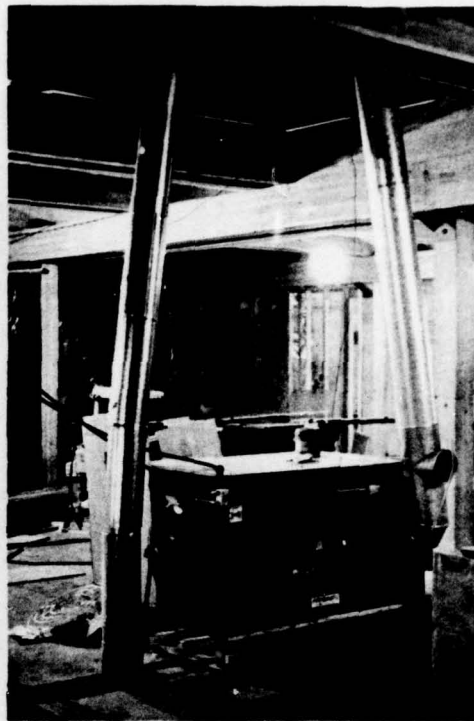
35. Close-up of ducting for Tioga heater,
Federal Building. November 24, 1976.
+120F.



36. Trailer mounted Tioga heater at Federal Building project.
November 24, 1976. +12°F.



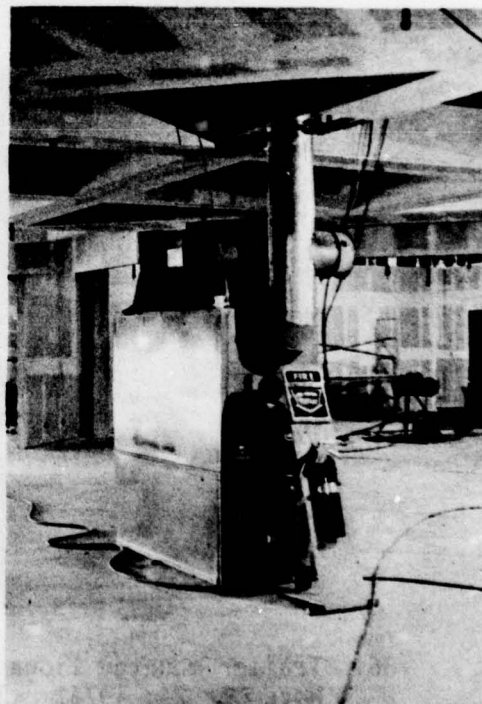
37. Space heater for temporary use at Interior Branch project. November 20, 1976. +7°F.



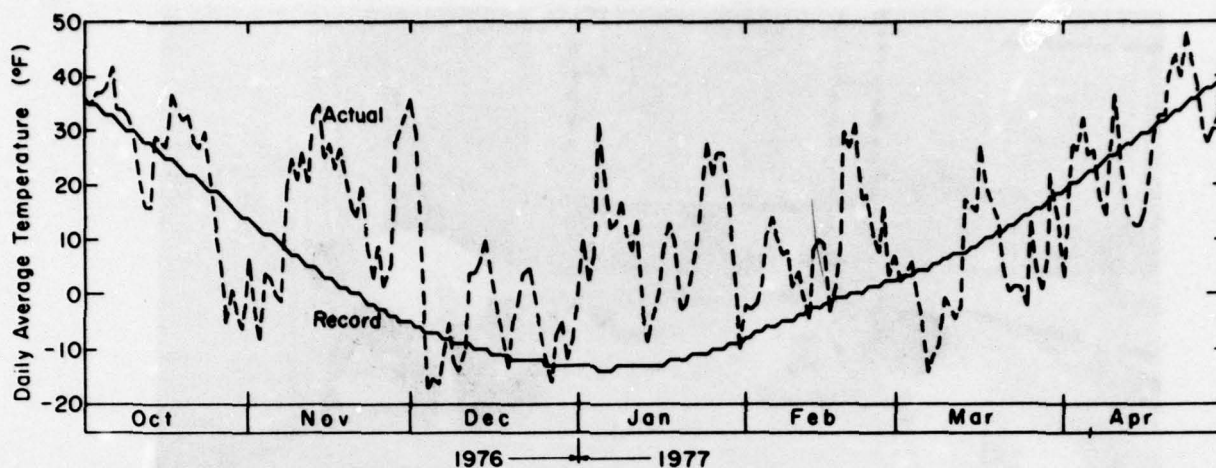
38. "Powrmatic" 450,000 BTU per hour furnace in operation at Plywood Supply project. December 30, 1976. -7°F.



39. "Master" heater drying a damp corner at University Mall project. January 6, 1977. +4°F.



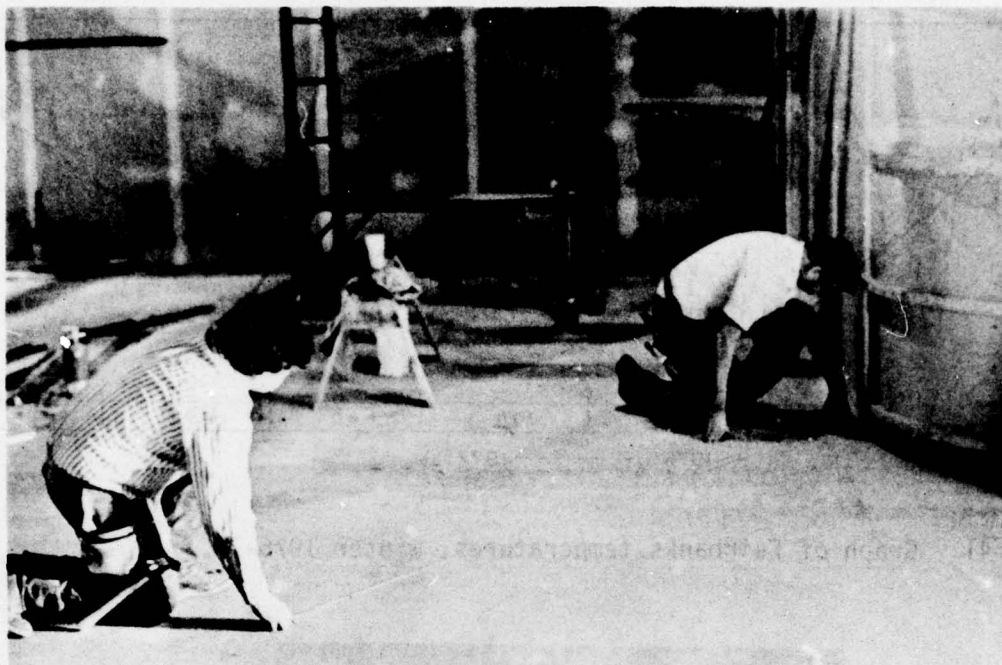
40. "Flexaire" 500,000 BTU per hour furnace in operation at University Mall project. January 19, 1977. -2°F.



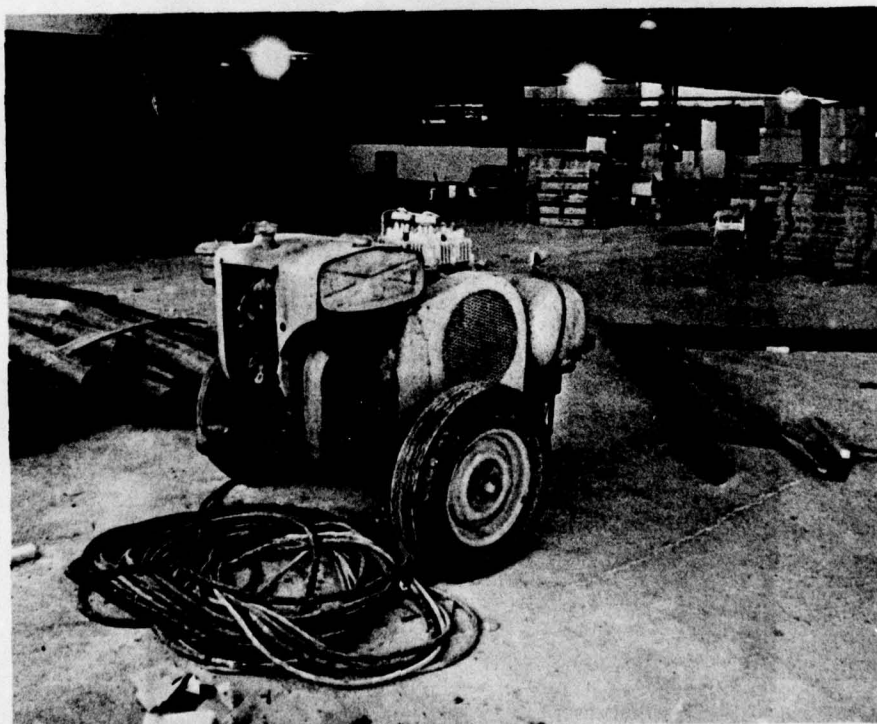
41. Graph of Fairbanks temperatures, winter 1976-77.



42. Workman completing the job in shirtsleeve comfort, Borough Library project. December 30, 1976. -12°F.



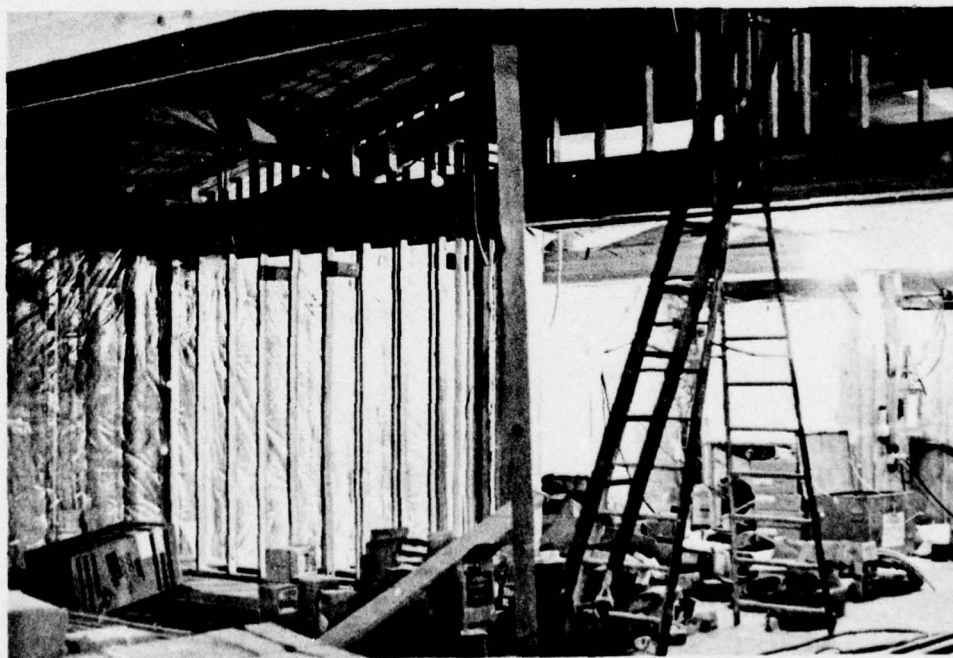
43. Carpenters laying out a reception area, Fairbanks Medical Clinic. January 6, 1976. +3°F.



44. Storage of equipment and materials at Federal Building parking garage. November 24, 1976. +12°F.



45. Ironworker installing bolts at Interior City Branch project. January 7, 1977. +14°F.



46. Interior of Plywood Supply project. December 30, 1976. -7°F.